Laminate Suspension System

Field of the Invention

The present invention relates to a glazing unit and particularly a novel glazing unit having unique means for mechanically fastening such glazing units to be fixed to a supporting structural glazing assembly for forming a continuous façade having an extensively smooth outer surface from such glazing units.

Description of the Prior Art

Various technological arrangements are known for mounting glazing units to provide the aesthetical and architectural benefits of continuous glazed façades which are typically fixed on high rise buildings. Generally the glazed façade assembly in the form of glass panels or units is mechanically secured to a substructure of the façade. The substructure is mounted on the outside of a load bearing building skeleton of metal or reinforced concrete. However, the means for mechanical fastening for this purpose involves some projecting parts and/or providing fastening holes through the layers of glass which distort the outer surface of the panels.

In an attempt to obtain the desired smooth outer surface of the façade form which no parts are projecting and the individual glass units remain integral, the glass panes were mounted exclusively by means of adhesive bonding. For safety reasons, building authorities have not generally permitted such glass facades without positive locking. Moreover, the prior art methods are limited to certain thickness of glass.

The current practice in façade construction is described in U.S. Patent No. 4,481,868 to McCann, which is incorporated herein by reference, discloses mechanically fastening sections of glass panels to the supports of a building. That patented glass

assembly comprises a planar array of sealed multiple glazing units each comprising two opposed spaced sheets with a seal between the sheets defining a sealed gas space, which units are secured to supporting members with the outer surface of the units sealed edge-to-edge, at least some of the units being secured to the supporting members by a mechanical fixing passing through the outer sheets of the units outside the seals of the units. In a preferred embodiment each unit is a multiple glazing unit which is secured to the supporting member by bolts whose heads are countersunk into holes countersunk in the outer face of the unit outside of the seal of the unit. The outer surface of the outside sheet of the glazing unit is protected against destructive stress cracks by cushioning with bushings and washers placed between the bolt and the glazing surfaces. The bushings and washers prevent glass-to-metal contact and prevent damage to the glazing sheets.

There are several disadvantages in the patented glass assembly directed to aesthetics and the manner of assembly. The holes required to accommodate the attaching bolts weaken the entire unit, destroy the integrity and smooth surface of the outer panel. The flat headed bolts even if countersunk into the glass detract from the uninterrupted planar appearance of the outside of the assembly. The necessity to carefully drill through multiple layers of glass and align these pieces constitutes a difficult and costly manufacturing problem. The drilling of glass to produce a countersunk hole usually requires two steps and may entail considerable glass breakage. Likewise, if the holes are not properly aligned, during assembly of the façade the tightening procedure will result in breakage resulting in down time and material loss.

The McCann patent does not disclose any laminated structure. The critical feature of the present invention is a glazing unit having embedded in an ionomer polymer layer a mechanical securing element.

It is known in U.S. Patent No. 2,310,402 to Dennison, which is incorporated herein by reference, to provide a glass insulation unit of a glass laminate wherein a metal border is embedded in plastic interlayers.

U.S. Patent No. 4,029,942 to Levin, which is incorporated herein by reference, discloses bus bars embedded in transparent laminates to provide electrical contacts to heat windows for defrosting and defogging.

U.S. Patent No. 4,799,346 to Bolton and Smith, which is incorporated herein by reference, discloses an attachment member mounting embedded in a transparent resinous layer of a laminate glazing unit. The attachment member mounting is fastened to a frame or support structure by bolting or clamping. In a preferred embodiment a resistance means for preventing removal of the mounting is in form of protrusions which extend from the plane of the member on that portion which is embedded within the interlayer. Among the resins suitable for use as interlayers for the laminate are mentioned ionomer resins.

The present case distinguishes from the Bolton and Smith patent in that the present invention is a glazing unit integrated with a mechanical securing element which eliminates the need for the attachment mounting element of the patent.

Summary of the Invention

According to the present invention a novel glazing unit is disclosed having at least one mechanical securing element embedded within a polymer layer, preferably an

ionomer, bonded to at least one monolithic glazing element to provide an integrated mounting system enabling such units to be fixed to a support without disruption or distortion of the monolithic structure of the glazing element. A plurality of glazing units are capable of being mounted in a planar array on the outer surface of a building having a concealed framework to produce a continuous glazed façade.

In its broadest aspect the present invention relates to a novel glazing unit comprising: at least one monolithic glazing element bonded to at least one polymeric layer having embedded therein a mechanical securing element selected from male or female interactive fastening means. Either the male of the female securing element can be embedded in the polymer. The invention is applicable to any glazing construction ranging from single laminates and/or multiple panes.

When a laminated multiple glazing unit such as a double glazing unit is involved, a hole or slot is formed in the internal glazing element to accommodate the stem of a male securing element. In a glazing façade assembly procedure the male stem is aligned with and passes through a hole or slot in a support structure regardless which securing element is embedded.

The external and/or internal glazing sheets may be any well known commercial plate, float or sheet glass composition. Also plastics which are well known in the plastics art such as polycarbonate polymers may be used either alone or in combination with glass glazing or with other plastics. An ionomer copolymer forms excellent strong bonds with glass, metals and plastic materials.

The polymers useful in this invention for forming a bonding layer (single glazing) or laminate interlayer and embedding a mechanical securing element are those capable of

providing the high tensile strength necessary to support multiple glazing units. Furthermore, the ionomer copolymer layer maintains the integrity of the glazing untis when they are subjected to physical impact or thermal stress.

It has been found that ionically crosslinked copolymers of ethylene-methacrylic or acrylic acid or ethylene-methacrylic or acrylic-acid-polyamine provides the toughness, high clarity, and superior tensile strength, are most useful. The ionomers are at least partially neutralized with an alkali metal cation.

The mechanical securing element which is embedded within the ionomer layer may be any male-female coacting mechanical fastening means. As mentioned above, either the male or the female securing elements can be embedded. The mechanical securing elements in combination are a means for securing the glazing unit to a supporting frame or other load bearing structure. Preferably, a bolt and nut provides a mechanical connection by simply screw-tightening the glazing unit against the supporting structure. Other mechanical securing combinations include snap together couplings, clamps, and the like.

A compressable and/or flexible material may be interposed at metal to glass or metal to plastic interfaces in the form of bushings, gaskets, sleeves, seals, or washers.

It is the primary object of the present invention to provide a glazing unit having means for securing the glazing unit to a frame or other structural support.

Another object of this invention is to improve the integrity of the glazing unit in the frame or structural support when subjected to high physical impact or thermal stress.

A further object of this invention is to ensure a safe retention of the glazing unit in position even in case of the breakage or cracking of the glazing element.

A still further object of this invention is that the glazing unit secured in the manner disclosed appears devoid of any projection or visible fixing element.

Yet another object of this invention is to provide a plurality of an improved glazing unit for producing a planar array on a building exterior having an uninterrupted surface, uniformity and continuity in reflection and color.

Still yet another object of the invention is to provide a laminate for the fixed windows of automobiles and aircraft such as windshields and canopies.

Other objects and a fuller understanding of the invention will be had by referring to the following description and claims of a preferred embodiment, taken in conjunction with the accompanying drawings, wherein like reference characters refer to similar parts throughout the several views.

Brief Description of the Drawings

Fig. 1 is a cross-sectional view of a single glazing unit having a male mechanical securing element, a bolt head, embedded in a bonded ionomer copolymer layer.

Fig. 2 is a cross-sectional view of a double glazing unit having a female mechanical securing element, a capped nut, embedded in the bonded ionomer copolymer layer.

Fig. 3 shows a sectional view of a plurality of the laminated glass glazing units **20** as illustrated in **Fig. 2** forming a glazing assembly of planar rectangular panels.

Fig. 4 is a cross-sectional view of a double glazing unit having a female securing element in the form of a flange and stud.

Fig. 4A is a cross-sectional view along line y-y of **Fig. 4**.

Detailed Description of the Preferred Embodiments

Referring to drawings Figs. 1 to 4, there are illustrated a novel single glazing unit, a laminated glazing unit and a glazing assembly according to this invention. A plurality of these glazing units when arranged in a planar array and mechanically secured to a concealed structural support member of a building form a glazing assembly having a monolithic façade with aesthetical and practical architectural benefits.

The simplest application of this invention as shown in **Fig. 1** involves a single monolithic glazing unit **10** which comprises a monolithic external glazing element **11** such as a glass glazing having a smooth outer surface **11a** and an inner surface **11b** bonded to an internal polymer layer **12** which is preferably an ionomer having surfaces **12a** and **12b** and embedded therein at least one male mechanical securing element **7** such as bolt **17**. The bolt **17** comprises a flat head **18** and a threaded stem **16**. As shown in the figure, the flat head **18** is totally embedded within the polymer layer **12** in a fixed position with the threaded stem **16** projecting from the glazing unit **10**. A female mechanical fixing element nut **19** is connected to the threaded stem **16** to form a mechanical securing assembly and enables the monolithic glazing unit to be secured to a structural support **14** (partially shown) by tightening the nut **19**. The inherent properties of adhesive strength and high tensile strength of the polymer locks the flat head **18**, increases the load bearing capacity of the mechanical securing assembly and accepts increased load bearing pressure.

In practice the installation of the monolithic glazing unit **10** to a support structure **14** involves passing the threaded end **16** of the bolt **17** through a bushing **13** and circular hole **15** of support structure **14**. The hole **15** has a diameter slightly larger than the threaded stem **16** to provide adequate clearance to compensate for the monolithic glazing

unit **10** which is secured to the support structure **14** by tightening nut **19** on the threaded stem **16** at face **12b** of the ionomer layer **12**. The tightening action causes pressure to be distributed through the bushing **13**. The bushing **13** is of sufficient size and elasticity to accommodate relative movements between the ionomer layer **12** and the structural support **14**.

A plurality of the monolithic glazing units **10** may be employed in a planar array as a building façade or an interior ceiling and wall assembly in which each of the laminated glazing units are secured to a support structure by mechanical securing assembly wherein at least one element of the assembly is embedded in the polymer layer of the laminate.

The term "monolithic" as used herein relates to a glazing element to be integral, i.e., without holes or fragmentations.

In **Fig. 2** there is shown a laminated multiple glazing unit, specifically a glass double glazing unit **20** comprising an external glass element **21** having an outer surface **21a** and an inner surface **21b** and an internal glass element **23** also having outer and inner surfaces **23a** and **23b** which are bonded together with polymer interlayer **22**. The interlayer **22** has embedded therein a female securing element such as a capped nut **27**. A circular fixing hole **24** is formed through the internal glass element **23** and has a diameter slightly larger than that of the mechanical fixing element **26**. In this case the male fixing element is a bolt **26** comprising a head **25** and a threaded end which is sized to engage the embedded capped nut **27**. As seen in **Fig. 3**, the laminated glazing assembly **30** (**Fig. 2**) is constructed from a plurality of laminate multiple glazing units. Each glazing unit has an uninterrupted outer surface which can be secured to a concealed supporting framework

to provide an uninterrupted planar appearance of the outside of the assembly. Preferably, the multiple glazing unit is a laminated glass double glazing unit **20** as described in **Fig. 2**. This glazing unit **20** is integrated with the mechanical connection with bolt **26**. The façade assembly procedure for attachment of each glazing unit **20** typically involves units having rectangular or square shapes with the mechanical securing element embedded in each corner. In this case the threaded end of bolt **26** is passed through hole **15** in support structure **14** through bushing **28** and through fixing hole **24** to connect with embedded capped nut **27**.

After engaging the capped nut **27** the bolt head **25** is torqued to exert force on bushing **28** which distributes the pressure to the inner surface **28** which distributes the pressure to the inner surface **23b** thus securing the glazing unit **20** to the support structure **14**. Various arrangements of compressible elastomeric gaskets, washers and seals in addition or in place of the bushing shown may be used to avoid glass-to-metal contact and prevent damage to the glazing sheets. Such arrangement and choice of compressable and/or flexible material is clearly known in the glazing art.

The critical feature of the invention resides in that at least one of the mechanical securing elements is embedded in an ionomer or polymer layer or interlayer. The mechanical securing assembly useful in this invention results from the interaction of male-female components either of which may be embedded in the ionomer layer without any consequence.

The terms "external" and "internal" as used herein refer to the position of these elements relative to the façade.

Fig. 3 illustrates a laminated glass double glazing assembly **30** comprising a planar array of laminated glass double glazing units **20** as shown in **Fig. 2** each of which are mechanically secured at their respective corners to conceal support members **14** behind the array which are part of a structural framework to which the glazing assembly **30** is secured. The outer glass glazing surface **21a** of the double glazing units **20** are positioned edge-to-edge so as to appear to be continuous. However, a small gap between adjacent edgers can remain and this can be sealed with a silicone sealant as indicated at **31** if required.

Fig. 4 shows another embodiment of this invention in which a female mechanical securing element **50** as shown in **Fig. 4A** is embedded in the polymer layer **42**. The construction of the securing element **50** involves a metal flange **49** attached to an internally threaded stud **48**. Additionally the flange has a plurality of spaced apart circular holes **51**. These holes provide additional surface areas for adhesion to the ionomer polymer layer **42**. The laminated double glazing unit **40** comprises external glass glazing element **41** and internal glass glazing element **43** bonded together with the polymer interlayer **42** having embedded therein the female securing element **50**. A bolt **45** having a threaded end provides the necessary male securing element. The bolt head **44** in torqued to tighten the glazing unit for attachment to a support structure **14**. In this construction the weight of the glazing unit is borne by the polymer layer **42**. Preferably, the flange and stud are welded together and employ stainless steel as the material of construction.

The glazing material preferred for either external or internal elements may be any with known commercial plate float or sheet glass compositions. The glass may be

tempered or non-tempered or chemically strengthened. Synthetic polymers to which the ionomer polymer resin provides good adhesion which includes polycarbonate resins, fused acrylic/polycarbonate resins, polyurethane, etc. The invention contemplates the use of one or more inner or outer layer of various polymer combinations preferably the inner layer is an ionomer layer and has embedded therein the mechanical securing element. The glazing material may range from transparent to opaque, may be tinted or deeply colored. The glazing material may include coatings which provide specific properties or special effects such as reflecting and non-reflecting properties, ultraviolet radiation absorbing, etc.

The thickness of the glazing may vary from about 8 mm to 19 mm for the external unit and between about 5 to 15 mm for the internal unit. The thickness of the ionomer polymer layer or interlayer will range from 3 to 60 mm. The good adhesion and the high tensile strength of the ionomer polymer allows for multiple glazing units in excess of three or more glazing elements. Further the thickness of each element may vary which allows for a wide latitude in glazing design.

Thermoplastic interlayer usable in the invention must be capable of strongly bonding to a rigid panel such as glass to form an impact-dissipating layer in a laminated safety glass assembly. Exemplary thermoplastics include poly(ethyl-vinyl acetate), poly(ethylene-vinyl acetate-vinyl alcohol), poly(ethylene-methyl, methacrylate-acrylic acid), polyurethane, plasticized polyvinyl chloride, polycarbonate, etc. Polyvinyl butyral (PVB) and more particularly partial PVB containing about 10 to 30 weight % hydroxyl groups expressed as polyvinyl alcohol is preferred. Such partial PVB further comprises about 0 to 2.5 weight % acetate expressed as polyvinyl acetate with the balance being

butyral, expressed as polyvinyl butyral. The non-critical thickness of the thermoplastic sheet can vary and is typically about 0.25 to 1.5, preferably about 0.35 to 0.75 mm. PVB sheet is commercially available from Monsanto Company as Saflex ® sheet and E.I. Dupont de Nemours and Co. as Butacite ® polyvinyl butyral resin sheeting.

Preferred interlayers are ionomers such as disclosed is U.S. Patent No. 5,763,062 and 4,663,228 which are herein incorporated by reference. Most preferable are the ionomers which have been at least partially neutralized with an alkali metal cation and a polyamine.

The mechanical securing assembly can be of a typical mechanical fastening means, besides the nut and bolt assembly mentioned above, various retention clamps, clips and means for snap together engagement are usable for this purpose. The glazing assembly is not only easy to install by virtue of the simple construction of the fixing means but the integrity of the external units is maintained so that continuous uninterrupted planar appearance of the outside assembly is provided. Suitable metals useful as materials for the mechanical securing assembly include aluminum and steel but preferably corrosion resistant materials such as stainless steel and high impact plastics including fiberglass and thermoset phenolic-aldhyde polymers.

Fixing inserts of compressable and/or flexible materials are used at metal-glazing material contact areas to prevent stress cracking as well as to improve impact resistance, compensation for thermal expansion and to secure watertightness. Fixing inserts of elastomeric material in form of bushings, gaskets, sleeves, spacers and washers are used in bolt-fixing insert, nut-fixing assembly systems. The specific securing assembly of the

mechanical connection will vary depending on the size and design of the individual glazing units and the final façade design.

Example 1

A windshield is prepared by inserting a 3-4 mm interlayer of an ionomer (NOVIFLEX ® sold by AGP Plastics, Inc. of Trumbauersville, PA.) between two sheets of glass of 10 mm thickness in which aligned holes are prebored partially in the ionomer and completely through the inside layer of the glass. A stainless steel stud having a tapered head with a standard 82 degree taper was inserted into the ionomer. The barrel of the stud is 20-25 mm in diameter and the head is tapped with a 9 mm coarse thread. A metal or plastic bushing is used to hold the inner glass layer in place. The assembly is placed in a so called "polymer" bag of the type disclosed in U.S. Patent No. 3,311,517 to Keslar et al. The bag comprises an outer ply of polyethylene terephthalate and an inner ply of polyethylene bonded thereto. The bag is inserted into a second bag evacuated and sealed. The unit is placed in an autoclave at 225°F for three minutes under 150-200 psi pressure in a vacuum. The vacuum causes the ionomer to flow and seal the opening and set the bolt.

If required, a large washer or metal strip with plastic cushioning may be used to tighten the assembly and to provide further security in the event that the outer glass is broken. Depending upon the size and weight of the laminate several fastening means can be used.

The form of the invention shown and described herein represents illustrative preferred embodiments and variations thereof. It is understood that various changes may be made without departing from the gist of the invention as defined in the claims.

Example 2

The preparation of a sample glass unit similar to that described in Fig. 2 was conducted as follows:

A cross-linked partially neutralized ethylene-acrylic acid ionomer resin was added to the resin port of a small extruder having an extruding barrel temperature which was maintained at 165-205°C. A film (50-60 mils) was extruded and cut into 12 squares of about 25.4 mm, stacked to about 13 mm thickness between two sheets of tempered glass one of which had a hole of 12 mm drilled in the center of the sheet. A 9 mm stainless steel capped nut was placed in the hole. The glazing unit was placed in a vacuum bag comprising an outer ply of polyethylene terephthalate and an inner ply of polyethylene bonded thereto. The bag was inserted into a second bag of the same material, evacuated and sealed. The sealed bag assembly was placed in an autoclave at 125°C for three minutes under 150-200 psi in a vacuum. The autoclave was reduced in pressure and cooled to room temperature. The bag assembly was removed from the autoclave and plastic wrappings were removed from the glass unit. This procedure embedded and fixed bonded the capped nut. A 9 mm stainless steel bolt was connected to and screwed into the fixed capped nut.

The glazing unit was then tested with tension applied at the head of the bolt. The indicated a strong adhesive bond of the ionomer polymer with the capped nut and a high tensile strength of the inherent in the ionomer layer.

It is intended that the primary use of the units constructed in accordance with the invention will be in the commercial glazing industry, particularly when flash glazing is required. In addition to this architectural glazing which can provide a desirable external

appearance due to the uninterrupted planar array of an outside assembly, the glazing units can provide the same effect for a decorative interior wall or ceiling. The glazing units of this invention can be used for automobiles and other vehicles. Multiple glazing units of this invention can be used in security glazing for banks, prisons, armored trucks, inter alia.

It will be understood that the above-described embodiments of the invention are only for the purpose of illustration. Additional embodiments, modifications and improvements can be readily anticipated by those skilled in the art based on a reading and study of the present disclosure. Such additional embodiments, modifications and improvements may be fairly construed to be within the spirit, scope, and purview of the invention as defined in the claims.